

DOCUMENT RESUME

ED 152 590

SE 024 156

AUTHOR Bonte, John L.; Davidson, Arnold C.
TITLE Free Carbon Dioxide. Training Module 5.245.2.77.
SPONS AGENCY Department of Labor, Washington, D.C.; Iowa State
Dept. of Environmental Quality, Des Moines.
PUB DATE Sep 77
NOTE 29p.; For related documents, see SE 024 138-165;
Contains occasional light and broken type in
transparency masters

EDRS PRICE MF-\$0.83 HC-\$2.06 Plus Postage.
DESCRIPTORS *Chemical Analysis; *Instructional Materials;
*Laboratory Techniques; *Post Secondary Education;
Secondary Education; *Teaching Guides; Units of
Study
IDENTIFIERS *Carbon Dioxide; *Water Treatment

ABSTRACT

This document is an instructional module package prepared in objective form for use by an instructor familiar with the titrimetric method and the nomographic method of determining free carbon dioxide concentrations of a water sample. Included are objectives, an instructor guide, student handouts, and transparency masters. A video tape is also available from the author. This module considers chemistry and principles of dissolved carbon dioxide, the preparation of standards and reagents, calculation of free carbon dioxide and the nomographic determination of free carbon dioxide.
(Author/RH)

* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY.

FREE CARBON DIOXIDE
Training Module 5.245.2.77

"PERMISSION TO REPRODUCE THIS
MATERIAL HAS BEEN GRANTED BY

Mary Jo Bruett

TO THE EDUCATIONAL RESOURCES
INFORMATION CENTER (ERIC) AND
USERS OF THE ERIC SYSTEM."

Prepared for the
Iowa Department of Environmental Quality
Wallace State Office Building
Des Moines, Iowa 50319

by

John L. Bonte
Developer
Arnold C. Davidson
Project Director
Clinton Community College
1000 Lincoln Boulevard
Clinton, Iowa 52732

The publication of these training materials was financially aided through a contract between the Iowa Department of Environmental Quality and the Office of Planning and Programming, using funds available under the Comprehensive Employment and Training Act of 1973. However, the opinions expressed herein do not necessarily reflect the position or policy of the U. S. Department of Labor, and no official endorsement by the U. S. Department of Labor should be inferred.

September, 1977

Module No:	Module Title: Free Carbon Dioxide
	Submodule Title:
Approx. Time: 4.0 hours	Topic: Summary

Instructional Objective:

Upon completion of this module the participant should be able to:

1. Determine the pH, temperature, and filtrable residue content of a water sample.
2. Calculate free CO₂ level by the nomographic method.
3. Determine the free CO₂ level by the titrimetric method.

Instructional Aids:

Transparency CD1 - CD4- Surface water videotape

Instructional Approach:

Lecture, demonstration, discussion, laboratory practice, videotape viewing.

References:

1. Standard Methods for the Examination of Water and Wastewater, 14 edition.
2. Operator's manual for pH meter.

Class Assignments:

Module No:	Module Title: Free Carbon Dioxide
	Submodule Title:
Approx. Time:	Topic:
0.5 hours	Chemistry of dissolved CO ₂

Instructional Objective:

Upon completion of this module the participant will be able to:

1. Describe how free CO₂ is related to corrosion and water hardness.
2. List the three forms of CO₂ in water.
3. Qualitatively relate the three forms to pH.

Instructional Aids:

Transparency CD1- three forms of CO₂ and pH.

Instructional Approach:

Lecture/discussion

References:

Standard Methods p. 293, 61-63.

Class Assignments:

Module No: CD	Topic: Chemistry of dissolved CO ₂
Instructor Notes:	Instructor Outline:
Transparency CD-1 Forms of CO₂ and pH	1. The gas, carbon dioxide reacts with pure water to form carbonic acid which will lower pH. CO₂ may react with CaO and other metal oxides to form CaCO₃ and other carbonates. Since CaCO₃ is only slightly soluble, the free CO₂ level and pH will determine the amount of hardness which will precipitate and whether a protective CaCO₃ coating will be in water mains. 2. Forms of CO₂ a. $\text{H}_2\text{CO}_3 = \text{CO}_2 + \text{H}_2\text{O}$ (Free CO₂) b. HCO_3^- bicarbonate c. CO_3^{2-} carbonate 3. pH and CO₂ a. low pH, H_2CO_3 b. intermediate pH, HCO_3^- c. high pH, CO_3^{2-}

Module No:	Module Title: Free Carbon Dioxide
	Submodule Title:
Approx. Time:	
0.25 hours	Topic: Safety

Instructional Objective:

Upon completion of this module the participant should be able to:

1. Locate the following in the laboratory and demonstrate proper use: emergency shower, fire extinguisher, eye wash, first aid kit.
2. Select and use safety glasses, lab coat or apron and gloves in appropriate situation.
3. Describe hazards involved with the chemicals used in determining CO₂.

Instructional Aids:

Laboratory safety rules handout.

Instructional Approach:

Lecture/demonstration

References:

Basic laboratory skills module.

Class Assignments:

Module No: CD	Topic: Safety
Instructor Notes:	Instructor Outline:
	1. Point out to students the location of various safety devices and their use. 2. Safety glasses should be worn during the preparation of reagents and during titration. 3. The Na_2CO_3 solutions are basic and may cause chemical burns.

Module No:	Module Title: Free Carbon Dioxide
Approx. Time: .5 hours	Submodule Title:
	Topic: Principles of CO ₂ measurement

Instructional Objective:

Upon completion of this module the participant should be able to:

1. List two methods for determining free CO₂.
2. List data needed for nomographic determination of CO₂.
3. Describe qualitatively the titrimetric method of CO₂ determination.

Instructional Aids:

Surface water analysis videotape.

Instructional Approach:

Lecture, discussion, videotape viewing

References:

Standard Methods, pp. 293 - 301.

Class Assignments:

Module No: CD	Topic: Principles of CO ₂ measurement
Instructor Notes:	Instructor Outline:
Surface water analysis Video tape - middle section	1. Show video tape - answer questions 2. Methods a. nomographic b. titrimetric 3. Nomographic data a. temperature b. pH c. total filtrable residue d. total alkalinity 4. Titration: The H₂CO₃ is consumed completely and converted to HCO₃⁻ by each mole of NaOH or Na₂CO₃

Module No:	Module Title: Free Carbon Dioxide
Approx. Time: 0.5 hours	Submodule Title:
	Topic: pH measurement

Instructional Objective:

Upon completion of this module the participant should be able to:

1. Describe the function of the pH meter.
2. Properly standardize the pH meter.
3. Determine the pH of a solution with a pH meter.

Instructional Aids:

Transparency CD2 - Diagram of pH meter.

Instructional Approach:

Laboratory practice

References:

Operator's manual for pH meter used.

Class Assignments:

Module No: CD	Topic: pH measurement
Instructor Notes:	Instructor Outline:
Transparency CD-2 Diagram of pH meter	1. Point out parts of pH meter a. meter b. calibration knob c. electrodes 2. Standardize against pH 7 buffer 3. Measure pH of any water solution

Module No:	Module Title: Free Carbon Dioxide
Approx. Time: 0.5 hours	Submodule Title:
	Topic: Filtrable Residue

Instructional Objective:

Upon completion of this module the participant should be able to:

1. Determine the concentration of filtrable residue in a water sample.
2. Differentiate between filtrable and non-filtrable residue.

Instructional Aids:

Transparency CD3 - filter apparatus

Instructional Approach:

Laboratory practice

References:

Standard Methods p.92

Class Assignments:

Module No: CD	Topic: Filtrable residue
Instructor Notes:	Instructor Outline:
Transparency CD-3 Filter apparatus	1. Filtrable residue a. filter sample through fritted glass b. evaporate filtrate to dryness c. weigh residue d. $\text{mg/l} = \text{mg residue/liters of sample}$ 2. Residue: a. filtrable - dissolved b. non-filtrable - suspended

Module No:	Module Title: Free Carbon Dioxide
	Submodule Title:
Approx. Time: 0.25 hours	Topic: Nomograph Method

Instructional Objective:

Upon completion of this module the participant should be able to:

1. Determine the free CO_2 level of a water sample from pH, residue, temperature and total alkalinity using a nomograph.
2. Determine the various types of alkalinity from pH, residue, temperature and total alkalinity.

Instructional Aids:

Transparency CD4- Free CO_2 Nomograph

Instructional Approach:

Lecture/discussion

References:

Standard Methods p. 294-298.

Class Assignments:

Module No: CD	Topic: Nomograph Method
Instructor Notes:	Instructor Outline:
Transparency CD-4 Free CO ₂ Nomograph, ruler	1. Describe steps in using nomograph by using data as follows: a. align temperature, 25° C b. total filtrable residue, 200 mg/l c. determine P₁ d. align pH, 7.5 e. bicarbonate alkalinity, 200 mg/l f. determine P₂ g. align P₁, P₂ h. read CO₂: 11.0 mg/l 2. The same procedure should be used on their data from residue, pH, and alkalinity determinations. 3. Point out that the forms of alkalinity can also be determined by nomograph given, pH, temperature, total alkalinity, residue.

Module No:	Module Title: Free Carbon Dioxide
Approx. Time: 0.25 hours	Submodule Title: Topic: Preparation of Standards and reagents

Instructional Objective:

Upon completion of this module the participant should be able to:

1. Prepare a standard Na_2CO_3 solution for free CO_2 determination.
2. Properly collect a water sample for CO_2 analysis.

Instructional Aids:**Instructional Approach:**

Laboratory practice

References:

Standard Methods p. 298-300.

Class Assignments:

Module No: CD	Topic: Preparation of standards and reagents
Instructor Notes:	Instructor Outline:
1. Na_2CO_3 solution: 2.407 g dissolved in water to make 1 liter. Distilled water should be boiled. Na_2CO_3 should be dry.	1. 0.0454 N Na_2CO_3 preparation 2. Collect sample in 500 ml Pyrex bottle - no trapped air. Syphon sample into graduated cylinder with overflow.

Module No:	Module Title: Free Carbon Dioxide
	Submodule Title:
Approx. Time: 0.5 hours	Topic: Titration and calculation of CO ₂

Instructional Objective:

Upon completion of this module the participant should be able to:

1. Titrate the sample with standard base to a predetermined end point or inflection point.
2. Calculate the concentration of free CO₂ from titration data.
3. List precautions to be taken in CO₂ analysis.

Instructional Aids:**Instructional Approach:**

Laboratory practice

References:

Standard Methods pp. 298-300.

Class Assignments:

Module No: CD	Topic: Titration and calculation of CO_2
Instructor Notes:	Instructor Outline:
	1. Titration a. add 5 drops phenolphthalein b. if solution turns red - no CO_2 c. if colorless add Na_2CO_3 solution from a buret, stir with glass rod until pink color persists, record ml Na_2CO_3 used. d. repeat but run in entire ml Na_2CO_3 from c. above. If necessary add more titrant to end point. 2. Calculation: a. red immediately $\text{CO}_2=0$ b. $\text{mg/l}(\text{CO}_2) = (\text{ml } \text{Na}_2\text{CO}_3) \times (.0454) \times 22,000$ ml sample 3. Precautions: a. glass-ware must be clean and free of acid or base residue b. titrate rapidly to prevent loss of CO_2 to the atmosphere during titration

Exam Questions

Free Carbon Dioxide Chemistry of Dissolved CO₂

1. If carbon dioxide is dissolved in distilled water will the solution be acidic or basic?
2. Three forms of CO₂ in water are free CO₂, bicarbonate, and _____.
3. At extremely high pH, CO₂ is mostly in the _____ form.

Safety

4. Chemicals splashed in the eye can be removed at the _____.
5. _____ will prevent the spillage of chemicals on the hands.
6. Na₂CO₃ will not "burn" when spilled on skin. True or False

Principles of CO₂ Measurement

7. Two methods of determining free CO₂ are the nomographic method and the _____ method.
8. The following data are needed for the nomographic method: pH, alkalinity, temperature, and _____.
9. At the end point of the titrimetric method, all the free CO₂ will be converted to _____ ion.

pH Measurement

10. The pH meter measures _____.
11. The pH meter is standardized with a _____ solution.
12. The pH of the solution is read on the _____ of the pH meter.

Filtrable Residue

13. A 50 ml sample contains 1.2 grams of residue. Calculate the concentration of residue in mg per liter.
14. Does filtrable residue include dissolved salts?

Nomograph Method

15. How many pivot lines are required for the determination of free CO₂?
16. Besides free CO₂, what else can be determined from a nomograph, residue, temperature, total alkalinity, and pH?

Preparation of Standards and Reagents

17. How should the water which is used for the preparation of titrant

be treated?

page 21 of 21

18. Why should care be taken to exclude air from a sample taken for free CO_2 analysis?

Titration and Calculation of CO_2

19. What is the color change in the CO_2 titration?
20. If 5.0 ml of 0.0454 N Na_2CO_3 is required to titrate a 100 ml water sample, what is the concentration of CO_2 in the sample?
21. Briefly describe how CO_2 is prevented from escaping or entering the water sample during collection or sampling.

FREE CO₂

EQUIPMENT AND SUPPLIES LIST

1. Free CO₂ nomograph (or as transparency CD₄)
2. thermometer
3. filter apparatus, filter flask, holder, glass fritted crucible
4. nickel crucible
5. oven
6. analytical balance
7. pH meter
8. pH 7 buffer
9. alkalinity test kit
10. sodium carbonate
11. distilled water
12. 2000 ml beaker
13. 1 liter volumetric flask
14. ringstand, ring, bunsen burner
15. 2 - 1 liter bottle
16. 100 ml graduated cylinder
17. rubber tubing
18. phenolphthalein indicator solution
19. 25 ml buret
20. glass stirring rod

Free Carbon Dioxide

Laboratory Procedure

I. Nomographic Method

A. Obtain a "free CO_2 " nomograph (transparency CD4 reproduced as a hand-out), a ruler and the following data for your sample.

1. temperature
2. total filtrable residue
3. pH
4. bicarbonate alkalinity

B. Sample data

data	1 25°C	2 25°C	3 12°C
temperature	25°C	25°C	12°C
total filtrable residue	700 mg/l	0 mg/l	200 mg/l
pH	8.5	7.6	6.0
bicarbonate alkalinity	300 mg/l	10 mg/l	2 mg/l

C. To use nomograph, (also: copies of the nomograph and nomographs for alkalinity may be obtained from The American Water Works Association, 666 West Quincy Ave, Denver, Colorado 80235.) Align temperature and total filtrable residue which determines P_1 point on line. Align pH and bicarbonate alkalinity which determines P_2 on line 2. Align P_1 and P_2 and read free CO_2 on each line. Using this procedure find free CO_2 for sample data 1, 2, 3, and for the sample provided by the student.

II. Titrimetric Method

- A. Prepare a standard sodium carbonate solution. Add 2.407g Na_2CO_3 to a 1 liter volumetric flask. Boil 1500 ml distilled water for 5 minutes; allow to cool. Fill the volumetric flask to the mark with this water. Label as: 0.0454 N sodium carbonate. Place in a bottle protected from atmospheric CO_2 .
- B. Collect a sample and analyze as soon as possible after collection by directing discharge into bottom of collection bottle. Protect from out-gassing or in-gassing. Syphon sample into 100 ml graduated cylinder allowing overflow. Flick sample to throw off sample above 100 ml mark.
- C. Add 5-10 drops phenolphthalein indicator. Add the Na_2CO_3 solution to a 25 ml buret. Record the initial buret reading. Dropwise, add Na_2CO_3 to the graduated cylinder with stirring until a pink color persists for 30 seconds. Record the buret reading. The difference in the two readings is the amount of titrant added.
- D. Calculate the free CO_2 level by multiplying the ml Na_2CO_3 added by 9.988. Comment on collection, storage, or other irregularities.

Data Sheet for Free Carbon Dioxide

I. Nomographic Method
Sample data

Free CO₂ 1 mg/l 2 mg/l 3 mg/l

Data from sample no

temperature °C

Filtrable residue mg/l

pH

Bicarbonate alkalinity mg/l

Calculated free CO₂ mg/l

II. Titrimetric Method

Sample no.

initial buret reading ml

final buret reading ml

ml Na₂CO₃ added ml (A)

Free CO₂ = 9.988 * A = mg/l

Comments:

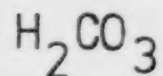
Analyst

Date

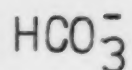
TRANSPARENCY CDI

Three forms of CO_2 and pH

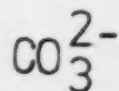
Carbonic acid(free CO_2)- low pH, acid



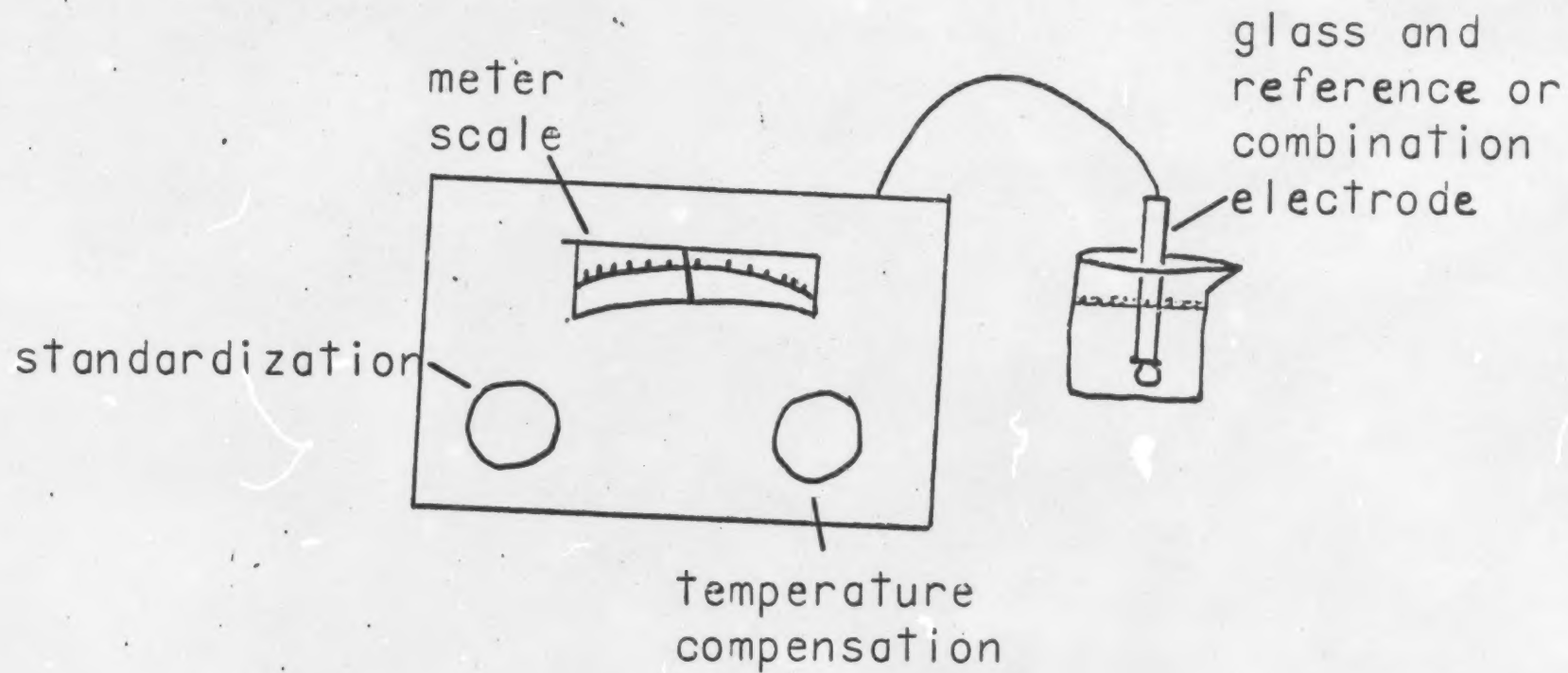
Bicarbonate-intermediate pH, neutral



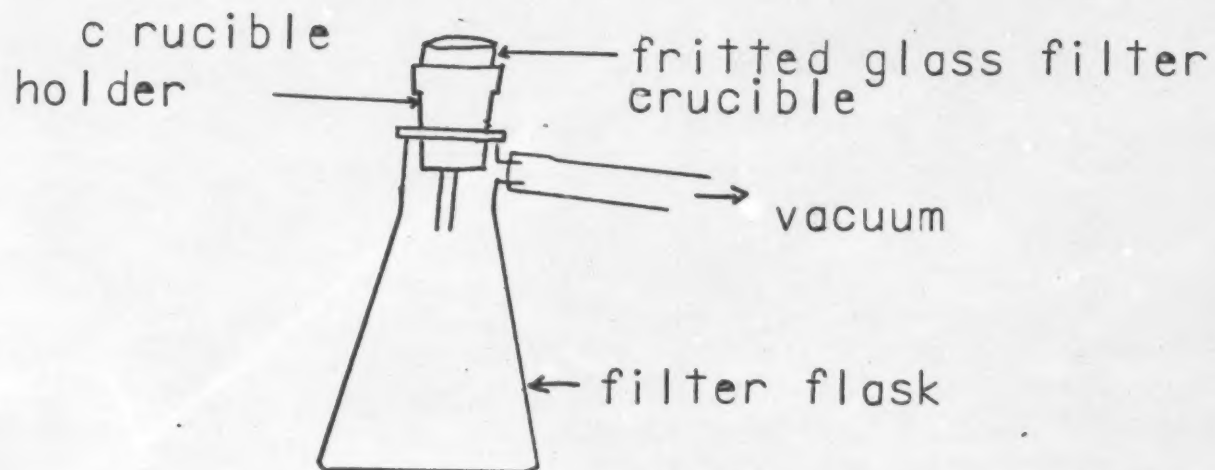
Carbonate- high pH, basic



TRANSPARENCY CD2
Diagram of pH Meter

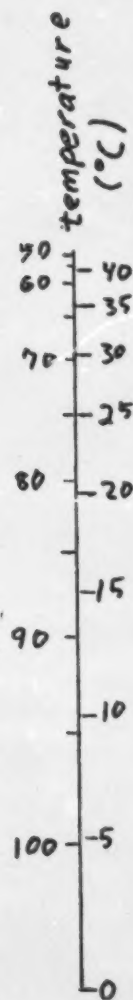


TRANSPARENCY CD3
Filter Apparatus

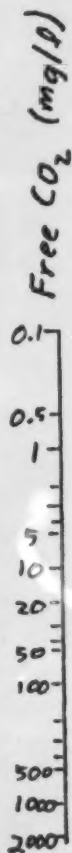
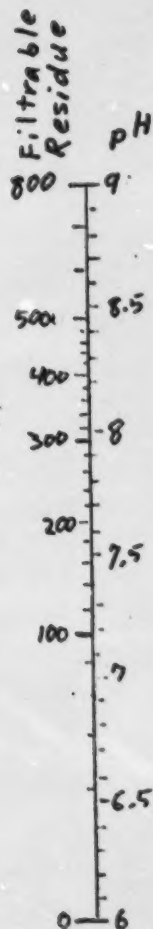


TRANSPARENCY CD4

Free CO₂ Nomograph



P₁



P₂

